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POLYAPHRON DISPERSIONS CONTAINING A COMPLEX INTERNAL PHASE

The present invention relates to a polyaphron dispersion.

5 A polyaphron dispersion is generally also known as a biliquid foam. This phrase is known, for example, from Sebba, F. (Felix), "Foams and biliquid foams, aphrons", 1987. ISBN: 0471916854. Biliquid foams are known in the art and are described in the following literature references by  
10 Sebba: "Biliquid foams", J. Colloid and Interface Science, 40 (1972) 468-474; and "The Behaviour of Minute Oil Droplets Encapsulated in a Water Film", Colloid Polymer Sciences, 257 (1979) 392-396.

15 US-A-4,486,333 to Sebba describes a particular method for the preparation of biliquid foams by agitating a hydrogen bonded liquid containing a soluble surfactant to produce a gas foam and intermittently adding to the gas foam a non-polar liquid which is immiscible with the hydrogen bonded  
20 liquid, the surfactant-containing hydrogen bonded liquid being selected to provide a spreading coefficient equal to or greater than zero.

Known polyaphron dispersions contain a single liquid  
25 external phase and a single liquid internal phase. We have now discovered a polyaphron dispersion which can contain additional phases in the internal phase, and a process for the preparation thereof.

30 Accordingly the present invention provides a polyaphron dispersion comprising an external phase and polyaphrons having an internal phase, the internal phase comprising (i)

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a first phase which is liquid and (ii) a second phase which is liquid or gaseous.

The process for preparing a polyaphron dispersion as defined  
5 above comprises (a) forming the internal phase and (b)  
forming a polyaphron dispersion comprising an external phase  
and the internal phase prepared in step (a).

The polyaphron dispersion preferably comprises from 70 to  
10 95% by weight of the internal and 5 to 30% by weight of the  
external, or continuous phase. The external phase is  
preferably an aqueous phase. It may also be composed of a  
liquid which has hydrogen bonding such as glycerin,  
propylene glycol and/or ethanol or a mixture thereof with  
15 water. A surfactant to stabilise the dispersion may also be  
included, for example in an amount of from 0.1 to 3%,  
preferably 0.1 to 1%, by weight based on the total weight of  
the dispersion. Suitable surfactants are, for example,  
anionic, cationic, non-ionic, amphoteric or zwitterionic  
20 surfactants, such as sodium lauryl ether sulphates,  
polyethoxylated castor oil, ethoxylated oleyl alcohols or  
polyethoxylated hydrogenated castor oils.

The internal phase comprises at least two liquid phases or  
25 at least a liquid phase and a gas phase. The internal phase  
may, of course, also comprise additional phases, such as an  
additional liquid phase, an additional gas phase or an  
additional solid phase.

30 The internal phase may, for example, comprise an aqueous  
phase and a non-aqueous phase, an emulsion or a biliquid  
foam (or polyaphron dispersion). The internal phase may

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also comprise a single aqueous phase and a single non-aqueous phase.

When the internal phase comprises an emulsion, the emulsion  
5 is, for example, a water-in-oil emulsion. The continuous  
phase of the emulsion is immiscible with the external phase  
of the polyaphron dispersion. The emulsion may, for  
example, comprise from 10% to 80% of the non-continuous  
10 phase and from 20% to 90% of the continuous phase. Either  
or both of the continuous phase and the non-continuous phase  
may comprise one or more additives, particularly additives  
which are incompatible with components of the external phase  
of the polyaphron dispersion. Examples of suitable oil  
15 phases are those mentioned below with respect to the  
internal phase when it is a polyaphron dispersion. An  
emulsion may be prepared by a standard techniques known in  
the art, for example by use of a pair heated vessels in  
which the aqueous and non aqueous phases are prepared prior  
to final mixing and emulsification by means of a high shear  
20 device such as a rotor stator device of the 'Silverson'  
type.

When the internal phase comprises a biliquid foam or a  
polyaphron dispersion (which may itself be a complex  
25 polyaphron dispersion of the present invention), the  
external phase may be aqueous or non-aqueous. The external  
phase of this internal phase is different from the external  
phase of the polyaphron dispersion of the invention. The  
internal phase may comprise from 10% to 80% of the non-  
30 continuous phase and from 90% to 20% of the continuous  
phase. Either or both of the continuous phase and the non-  
continuous phase may comprise one or more additives,

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particularly additives which are incompatible with components of the external phase of the polyaphron dispersion. Examples of suitable oil phases are oils which are liquid at room temperature (e.g. 20 degrees C) such as, for example, one or more selected from a cyclomethicone, dimethicone, dimethiconol, dimethicone copolyol, an emollient ester such as isopropyl stearate, lanolate, myristate or palmitate, or octyl palmitate, a glyceride such as avocado oil, coconut oil, soybean oil or sunflower oil, or a caprylic/capric triglyceride, a lanolin oil, mineral oil or natural oil, or oleyl alcohol, or any other oil known to be used in emulsions for whatever purpose. Also included in the definition of oil are water insoluble solvents such as hexane, toluene, benzene, kerosene, diesel oil and other like solvents and water-insoluble organic liquids. The biliquid foam or polyaphron dispersion may be prepared by a standard techniques known in the art, for example by those indicated herein.

When the internal phase comprises a single aqueous phase and a single non-aqueous phase, it may be prepared by forming an unstable emulsion or polyaphron suspension, which is subsequently allowed to separate into two components on standing once the polyaphron suspension of the present invention is fully formed.

The external and/or internal phase of the polyaphron dispersion may, for example, comprise one or more surfactants or other additives. Suitable surfactants for forming and stabilising biliquid foams or polyaphrons can be selected for example, from the list given in WO 97/32559 or will be well-known to those skilled in the art. Methods of

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producing biliquid foams are described in US-A-4,486,333 involving the preliminary formation of a gas foam in order to provide a sufficiently large surface area on which the biliquid foam can subsequently be formed. It has been found  
5 that the prior formation of a gas foam is not required to manufacture a stable biliquid foam, provided that a suitable stirring mechanism is provided in the manufacturing vessel.

Such an apparatus comprises a tank provided with a stirrer  
10 in which the stirrer blade breaks the interface between the liquid and air and provides low shear mixing throughout the whole of the volume of the biliquid foam throughout the whole of the production process. A delivery device is provided through which the internal phase of the dispersion,  
15 which in this case comprises at least two liquids, is delivered to the tank. The design of the delivery device is such that the rate of addition of the internal phase fluid can be controlled and varied during the production process. A feature of the production process is that the internal  
20 phase is added to the stirred external phase slowly at first until sufficient droplets have been formed to constitute a large, additional surface area for the more rapid formation of new droplets. At this point, the rate of addition of the internal phase may be increased.

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The production process preferably comprises the following steps:

1. The addition of one or more chosen surfactants to one or other or both phases (as previously  
30 determined by experiment).
2. The charging of the external phase into the bottom of a process vessel.

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3. The incorporation of the stirrer into the vessel so that it stirs the surface of the external phase.
4. Adjustment of the stirrer speed to a previously  
5 determined level.
5. The slow addition of the internal phase whilst continuing to stir at the prescribed speed.
6. The speeding up of the rate of addition of the  
10 internal phase once a prescribed amount (usually between 5% and 10% of the total amount to be added) has been added.

The stirring rate and the rate of addition of the internal phase are variables, the values of which depend upon the  
15 detailed design of the manufacturing plant (in particular, the ratio of tank diameter to impeller diameter), the physico-chemical properties of the internal phase and the nature and concentrations of the chosen surfactants. These can all be pre-determined by laboratory or pilot plant  
20 experiment.

It will be understood by those skilled in the art that other manufacturing methods for the polyaphron dispersion may be used, as appropriate.

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Colloidal gas aphrons are known in the art as, for example, described by Sebba in "Foams and biliquid foams, aphrons", 1987. ISBN: 0471916854. Such colloidal gas aphrons containing a gas such as air, nitrogen, carbon dioxide or a  
30 reactive gas such as oxygen or hydrogen may constitute the internal phase of the current invention. Colloidal gas aphrons may be prepared as described in the stated reference

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or by a sparging process, which may include the use of a porous material through which the gas is injected into a suitably prepared water insoluble medium containing surfactants. Alternatively, the gas may be injected into a water-insoluble medium having a sufficient viscosity and or yield value to prevent the agglomeration of individual gas bubbles until the polyaphron dispersion of the present invention is fully prepared.

10 In one application of the invention, there is produced a food product such as a rich and creamy yoghurt type food product wherein the external phase is aqueous and may contain water soluble flavours, fruit extracts or particles of fruit, water-soluble colouring agents and the like, 15 whereas the internal phase comprises an edible oil (preferably non fattening) such as olive oil or sunflower oil or avocado oil and an internal water phase which may be as high as 80% of the total internal phase concentration. The total concentration of the complex internal phase may be 20 as high as 95% but is preferably about 90%, at which concentration the product has a rich and creamy appearance and taste because of the high concentration of the internal phase. In this manner is produced a low fat, high water content food product containing about 72 - 80% water phase.

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In another application there is produced a self-heating preparation consisting of two or more chemicals capable of undergoing an exothermic reaction when mixed where at least two of the reactants are water-soluble. In this 30 application, at least one reactant is contained in the internal phase and another in the external continuous phase. The composition is such that the reacts do not mix and do

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not, therefore, undergo an exothermic reaction until the two aqueous phases are mixed during use. By this means, a self-heating composition such as a cosmetic or pharmaceutical composition, preferably in the form of a cream, may be  
5 produced providing the reactants are not harmful to human skin.

In a further application there is produced a composition comprising two or more separate and different complex  
10 polyaphrons comprising different internal phases dispersed into the same liquid external phase. The external phase may or may not be polymerised at a later stage. This system could give rise to a multi functional product, whereby each complex bi-liquid foam may contain a different active to  
15 perform different tasks upon a different stress. Thus a single formulation could be provided, for example having the ability to change colour permanently once cooled, and a different colour once heated and containing two incompatible drug systems.

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We have surprisingly found that at least one of the internal liquid phases is in equilibrium with the external phase such that if the external phase is diluted, the internal phase will begin to release active components contained in it at a  
25 controlled rate. Thus, for example compositions containing a hydrogen bonded external phase and at least one hydrogen bonded internal phase can be caused to release an active such as an enzyme from the internal phase by diluting the external phase.

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The composition of the present invention can be made, for example, at room temperature and low shear and can thus be very useful for enzymes or condition sensitive actives.

- 5    Modification of the viscosity profiles of the internal phases and external phase by viscosity modifiers, known to those skilled in the art, can be adjusted to influence the droplet size and aphron strength during manufacture.
- 10   Further examples of use of reacting species separated in the two aqueous phases until used include the formulation of adhesive products wherein at least one hydrogen bonded phase such as an aqueous phase contains a suitable adhesive precursor such as a polymer and the other at least one
- 15   initiator species.

In a similar manner, the present invention allows there to be used a colour change reaction (such as, for example, a reaction using a pH sensitive dye, such as bromothymol blue

20   on the one hand and an acid or base solution on the other).

In yet a further application, the two aqueous phases may be used to keep separate two materials which are mutually incompatible until the moment of use. An example would be

25   the delivery vehicle for two drugs which would precipitate out of solution when combined together (as might be the case, for example, is one drug was anionic in character and the other cationic).

- 30   The present invention is now further described in the following Examples.

## EXAMPLES

## PREPARATION OF WATER IN OIL EMULSIONS

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## Preparation Example 1

A "water in oil" emulsion was prepared from the following ingredients.

10	Ingredients	Weight (g)	%
	<b>Aqueous Phase</b>		
	1% Sodium chloride in demineralised water	50	50
	<b>Oil Phase</b>		
15	Dow Corning 5200 formulation aid	4.0	4.0
	Medium viscosity white mineral oil	46	46
	Total	100	100

20 The water in oil emulsion was prepared in a 250ml Beaker with a diameter of 6.5cm. The aqueous phase was added to the oil phase while being stirred at approximately 2000rpm for 15 minutes with an impeller of diameter 5.5cm.

## Preparation Example 2

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A "water in oil" emulsion was prepared from the following ingredients.

	Ingredients	Weight (g)	%
	<b>Aqueous Phase</b>		
30	1% Sodium chloride in demineralised water	100	50.0
	<b>Oil Phase</b>		

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Dow Corning 5225c formulation aid	7.40	3.70
Phenyl trimethicone	92.6	46.3
Total	200	100

5 The water in oil emulsion was prepared in a 500ml Beaker with a diameter of 6.5cm. The aqueous phase was added to the oil phase while being stirred at approximately 4500rpm for 10 minutes with a rotor stator.

#### 10 Preparation of Complex Biliquid foams

##### Example 1

	Ingredients	Weight (g)	%
15	Preparation 1	90	90
	PEG 40 Castor Oil	1.0	1.0
	Demineralised water	8.9	8.9
	Methyldibromo Glutaronitrile	0.1	0.1
20	(and) Phenoxyethanol (preservative)		
	<b>Total</b>	100	100

The PEG 40 castor oil and the preservative were dissolved into the water in a 250ml Beaker. Preparation 1 was then  
25 added to the beaker dropwise, at first, with a stirrer speed of 350rpm and an impeller of diameter 5.5cm. As more of preparation 1 was added, the impeller speed was reduced and the rate of addition increased, until total addition of preparation 1 and a stirrer speed of 150rpm.

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## Example 2

	Ingredients	Weight (g)	%
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	Preparation 2	180	90
	Laureth-7	1.8	0.9
	Sodium Laureth sulphate	2.0	0.1
	Demineralised water	17.8	8.9
10	Diazolidinyl urea, Iodopropynyl butylcarbamate, Propylene glycol (preservative)	0.2	0.1
	<b>Total</b>	<b>100</b>	<b>100</b>

- 15 The Laureth-7, sodium laureth sulphate and preservative were added to the water and mixed gently in a 500ml beaker with a flat bladed stirrer. Preparation 2 was then added to the beaker dropwise, at first, with a stirrer speed of 200rpm. The stirrer speed was reduced as more of preparation 2 was
- 20 added.